

SENSORIMOTOR ADAPTATION FOLLOWING EXPOSURE TO AMBIGUOUS INERTIAL MOTION CUES

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INTRODUCTION

The central nervous system must resolve the ambiguity of inertial motion sensory cues in order to derive accurate spatial orientation awareness. Our general hypothesis is that the central nervous system utilizes both multi-sensory integration and frequency segregation as neural strategies to resolve the ambiguity of tilt and translation stimuli. Movement in an altered gravity environment, such as weightlessness without a stable gravity reference, results in new patterns of sensory cues. For example, the semicircular canals, vision, and neck proprioception provide information about head tilt on orbit without the normal otolith head-tilt position that is omnipresent on Earth. Adaptive changes in how inertial cues from the otolith system are integrated with other sensory information lead to perceptual and postural disturbances upon return to Earth's gravity. The primary goals of this ground-based research investigation are to explore physiological mechanisms and operational implications of disorientation and tilt-translation disturbances reported by crewmembers during and following re-entry, and to evaluate a tactile prosthesis as a countermeasure for improving control of whole-body orientation during tilt and translation motion.

SPECIFIC AIMS

The first specific aim of this proposal will be to examine the effects of stimulus frequency and different patterns of inertial sensory cues on adaptive changes in eye movements and motion perception during combined tilt and translation motion profiles. Subjects will be exposed to various combinations of tilt and translation motion profiles over the frequency range from 0.15 Hz to 0.6 Hz. During a 'vision aligned' paradigm, tilt chair motion will be coupled with translation visual scene motion aligned with the horizontal head axis, resulting in a visual-vestibular mismatch in which both canals and otoliths signal tilt while vision does not. During a second 'GIF aligned' paradigm, the chair will tilt within an enclosure that will simultaneously translate so that the resultant gravito-inertial force (GIF) vector remains aligned with the longitudinal body axis, resulting in a mismatch in which the canals and vision signal tilt while the otoliths do not. Changes in eye movement and perceptual tilt responses will be determined by comparing pre- and post-adaptation runs performed in darkness. The tilt and translation profiles will be restricted to one plane at a time to compare adaptation when using either pitch tilt with fore-aft translation or roll tilt with lateral translation. For our second specific aim, we will employ a closed-loop nulling task in which subjects will be tasked to use a joystick to null out tilt motion disturbances with or without concomitant translation motion. Changes in control errors will be determined by comparing subject performance in darkness before and after exposure to the 'GIF aligned' adaptation paradigm described above. Our third specific aim is to utilize the 'GIF aligned' adaptation paradigm to evaluate how a tactile prosthesis might improve control performance. Repeated measures will be utilized to compare post-adaptation control performance with no tactile information and with tactile feedback using both position and velocity errors. The results of this study will contribute to the refinement of the tactile prosthesis to improve spatial orientation and navigation on different acceleration platforms, including landing systems used for return to Earth after long-duration space travel or during space exploration missions.

CURRENT STATUS AND PLANS

The funding for this grant recently started in September 2004. Studies during the first year will compare sensorimotor adaptation in pitch and roll planes using the 'vision aligned' paradigm with the JSC Neuroscience Laboratory Tilt-Translation Device. A combination linear sled and tilt chair is under development at the Naval Aerospace Medical Research Laboratory to provide the 'GIF aligned' paradigm for studies in Years 2-4. Preliminary results will be presented comparing postural performance without tactile feedback, with tactile feedback of sway position and velocity, ^{and} ~~or~~ with tactile feedback of head position and velocity.

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